REMARKS

These Amendments and Remarks are being filed in response to the Office Action dated February 26, 2002. For the following reasons, this Application should be in condition for allowance and the case passed to issue.

No new matter is introduced by this amendment. The amendment to the specification merely corrects minor informalities. The amendment to claim 1 is supported by the specification at page 4, line 17 to page 5, line 11; page 5, line 24 to page 6, line 1; and FIG. 1a.

Claim Rejections Under 35 USC § 103

Claim 1 is rejected under 35 USC § 103(a) as being unpatentable over Ulmer (U.S. Patent No. 6,138,894) in view of Tsujino (U.S. Patent No. 6,299,015). This rejection is traversed, and reconsideration and withdrawal thereof respectfully requested. The following is a comparison of the instant invention and the cited prior art.

An aspect of the invention, per claim 1, is a flip chip bonding method for mounting a semiconductor element on a wiring board comprising the steps of applying a vacuum to the semiconductor element through an ultrasonic bonding head to fixedly attach the semiconductor element to the ultrasonic bonding head. Pressure and heat is applied to solder bumps, formed on both or one of a connecting pad of the semiconductor element or a connecting pad of the wiring board for connecting the solder bumps under a state that the solder bumps are in contact, heated to a temperature more than the fusing point of the solder, and fused while the ultrasonic bonding head is moved in a plurality of directions or along a circular locus.

The Examiner asserts that Ulmer teaches applying pressure and heat to solder bumps, formed on both or one of a connecting pad of a semiconductor element or a connection pad of the wiring board for connecting the solder bumps under a state that the solder bumps are in contact and fused while an ultrasonic head is moved. The Examiner further asserts that Tsujino teaches moving a bonding head in a plurality of directions. The Examiner concludes that it would have been obvious to move the bonding head of Ulmer as taught by Tsujino in order to provide an excellent bond.

Ulmer and Tsujino, taken alone or in combination, fail to teach the claimed method. Neither Ulmer or Tsujino teaches nor suggests the step of applying a vacuum to the semiconductor element through an ultrasonic bonding head to fixedly attach the semiconductor element to the ultrasonic bonding head, as required by claim 1.

Furthermore, claim 1 requires the solder bumps to be heated to a temperature more than the fusing point of the solder. Ulmer, however, discloses that the solder bumps are heated to about the melting temperature of the solder (column 4, lines 33-35). In addition, none of the cited references suggest moving the ultrasonic bonding head in *in a plurality of directions or along a circular locus*. Heating the solder bumps to more than the fusing point of the solder bumps and moving the ultrasonic bonding head in a plurality of directions or along a circular locus causes the oxide films to efficiently migrate to the inside of the solder bumps. Migration of the oxide layer to the inside of the solder bumps allows bonding without the use of flux. This benefit is neither disclosed nor suggested by the prior art.

Claim 2 is rejected under 35 USC § 103(a) as being unpatentable over Ulmer and Tsujino, and further in view of Kuriyama (U.S. Patent No. 5,315,474). This rejection is traversed, and reconsideration and withdrawal thereof respectfully requested.

The Examiner avers that Kuriyama teaches an inactive or reducing atmosphere during bonding. The Examiner concludes it would have been obvious to use a particular gas in order to prevent oxidation of the bonding surfaces.

Kuriyama, however, does not correct the deficiencies of the Ulmer and Tsujino references. Therefore, claim 2 is allowable for at least the same reasons as claim 1.

In light of the Amendments and Remarks above, this application should be considered in condition for allowance. If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated to expedite the prosecution of the application.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE."

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The paragraph beginning at line 17 of page 1 has been amended as follows:

--However, the conventional flip chip bonding method uses flux. Flux removes oxide films on surfaces of solder bumps and to facilitate connections by solder. However, if the quantity of the flux is not optimized or a step of cleaning is not controlled, there are problems that the flux is left as propellant fouling after the step of cleaning, and the propellant fouling prevents a sealing resin from being injected in a later step, whereby voids are induced, [an] yield is dropped, and reliability is spoiled.--

The paragraph beginning at line 18 of page 4 has been amended as follows:

--The solder bumps 3 are located on the connecting pad of the semiconductor element 1 and the connecting pad of the wiring board 2. Flux is not supplied to the solder bumps 3, located on the semiconductor element 1 and the wiring board 2, according to Embodiment 1. An ultrasonic bonding head 4 sucks the semiconductor element 1 by vacuum and can apply an ultrasonic wave while heating the semiconductor element 1 from a room temperature to 400°C. In a bonding stage 5, a heater is [build-in] built-in to previously heat the wiring board 2 to a temperature around a fusing point of solder.--

The paragraph beginning at line 3 of page 5 has been amended as follows:

--As illustrated in Figure 1a, the wiring board 2 is registered and mounted on an upper surface of the bonding stage 5, heated to around the fusing point of solder. On the other hand, the semiconductor element 1 is sucked on a lower surface of the ultrasonic bonding head 4, heated to less than the fusing point of solder. The semiconductor element 1

is positioned above the wiring board 2 so as to be aligned by a horizontal movement of the ultrasonic bonding head 4.--

The paragraph beginning at line 12 of page 5 has been amended as follows:

--As illustrated in Figure 1b, the ultrasonic bonding head 4 is [downward moved] moved downward, and the semiconductor element 1 is mounted at a predetermined position on the wiring board 2. Under this state, since the semiconductor element is sucked on the lower surface of the ultrasonic bonding head 4, the semiconductor element is in contact with the wiring board 2 with pressure by application of a pressure for a predetermined time in a vertical direction. Therefore, it is possible to increase contact areas of all the solder bumps 3, and it possible to previously break parts of oxide films on the solder bumps 3.--

The paragraph beginning at line 11 of page 6 has been amended as follows:

--[Succeedingly] Subsequently, as illustrated in Figure 1e, by cooling the ultrasonic bonding head 4 to be a temperature of the fusing point of solder or less, a temperature of the semiconductor element 1 is decreased, and the solder bumps 3 are [solidificated] solidified by the temperature decrement. Thereafter, the suction of the semiconductor element 1 is released and the ultrasonic bonding head 4 is raised, wherein the flip chip bonding is completed.--

IN THE CLAIMS:

Claim 1 has been amended as follows:

1. (Amended) A flip chip bonding method for mounting a semiconductor element on a wiring board comprising steps of:

applying a vacuum to the semiconductor element through an ultrasonic bonding head to fixedly attach the semiconductor element to the ultrasonic bonding head; and

applying a pressure and heat to solder bumps, formed on both or one of a connecting pad of the semiconductor element or a connecting pad of the wiring board for connecting the solder bumps under a state that the solder bumps are in contact, heated to a temperature more than the fusing point of the solder, and fused while [an] the ultrasonic bonding head is moved in a plurality of directions or along a circular locus.